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Near-horizon circular orbits and extremal limit for dirty rotating black holes

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Abstract

© 2015 American Physical Society. We consider generic rotating axially symmetric "dirty" (surrounded by matter) black holes. Near-horizon circular equatorial orbits are examined in two different cases of near-extremal (small surface gravity κ) and exactly extremal black holes. This has a number of qualitative distinctions. In the first case, it is shown that such orbits can lie as close to the horizon as one wishes on suitably chosen slices of space-time when κ→0. This generalizes the observation of T. Jacobson [Classical Quantum Gravity 28, 187001 (2011)CQGRDG0264-938110.1088/0264-9381/28/18/187001] made for the Kerr metric. If a black hole is extremal (κ=0), circular on-horizon orbits are impossible for massive particles but, in general, are possible in its vicinity. The corresponding black hole parameters determine also the rate with which a fine-tuned particle on the noncircular near-horizon orbit asymptotically approaches the horizon. Properties of orbits under discussion are also related to the Bañados-Silk-West effect of high energy collisions near black holes. Impossibility of the on-horizon orbits in question is manifestation of kinematic censorship that forbids infinite energies in collisions.

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